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Frequency	Reproducibility
Deviation	Stability

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Outlines test procedures and methods for use in evaluating the performance of radio transmitters, specifically relating to frequency accuracy and stability, over a range from 14 KHz to 12,000 MHz.

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US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-105 31 December 1980
*Test Operations Procedure 6-2-517
AD No. A100394

TRANSMITTER FREQUENCY ACCURACY AND STABILITY

1. SCOPE. These test procedures outline the techniques and procedures to be used in evaluating the performance of radio transmitters specifically relating to frequency accuracy and stability over the frequency range from 14 KHz to 12,000 MHz.

1.1 Characteristics. The three frequency accuracy and stability characteristics to be reported are:

1.1.1 Deviation. The objective of tests designed to report deviation is to determine the degree of deviation of the measured carrier frequency and the test item's indicated frequency (dial, meter, read-out display, detent, channel selector, etc.).

1.1.2 Accuracy and Reproducibility. The objective of the tests designed to report accuracy and reproducibility is to determine the degree of deviation between the measured carrier frequency and the test item's indicated frequency (dial, meter, read-out display, detent, channel selector, etc.) after both repeated changes of frequency (or tuning) and variations of input voltage levels.

1.1.3 Stability. The objective of the tests designed to report stability is to determine the ability of the test item to produce the same frequency over a specified period of time and to determine the degree of variations that may occur.

1.2 Limitations.

1.2.1 These procedures address only those transmitters that operate within the .014 to 12,000 MHz band.

*This TOP supersedes MTP 6-2-517, 1 May 1967.

1.2.2 These procedures assume that the signal-to-noise ratio (s/n) is adequate to activate the frequency measuring devices without causing ambiguous readings.

1.2.3 These procedures are conducted in a laboratory and proving ground environment and therefore do not address any environmental tests.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

ITEM	REQUIREMENT
Floor and/or bench space	Under ambient laboratory conditions, enough space available for the equipment under test, ancillary equipment, and instrumentation.
Screen room (shielded enclosure)	Under closed-system setup for electronically quiet environmental conditions. (Screen room is desirable for open-system setup if the equipment undergoing test, ancillary equipment, and instrumentation can be fitted); 100 dB attenuation of all radiated fields.
Electrical power	Dependent upon the equipment undergoing test and the required instrumentation, but generally includes 117 v AC and 220 v AC, single and three phase (Y and Delta); ±5% of nominal rms volts.
Field ranges	Under open-system setup with equipment too large for indoor setup, field range located in electronically quiet area.

2.2 Instrumentation

2.2.1 The specific instrumentation requirements are dependent upon the design of the equipment under test and the specific test procedures employed. The test officer, in developing the detailed test plan, shall select the instrumentation that meets the following requirements and standards (all measurement apparatus shall bear current calibration tags; all transfer standards relating the measurement apparatus to an identified master standard shall be recorded):

ITEM	MINIMUM ACCURACY OR PURPOSE
Frequency counter	± 1 part per million
RF signal generator	± 2 dB output level
Voltmeter - field intensity meter (frequency selective vm)	± 1.5 dB output
Power supply	± 5% of nominal rms volts
RF resisitive load (dummy antenna)	Of adequate power capability to dissipate RF power, ± 0.5% of load impedance (ohm)
Matching pads (coupling device)	± 0.5 dB

3. PREPARATION FOR TEST.

3.1 Planning. The test officer must assure himself that the test plan will sufficiently exercise the test item to accomplish the reasons for undertaking the test. For development tests (DT), the Independent Evaluation Plan (IEP) and the Test Design Plan (TDP) will usually outline the particular requirements to be included in the test plan. The assigned test officer will activate a project notebook for each test item, recording in it pertinent descriptive and technical information. The project notebook provides a narrative discussion of test conduct and results and is kept current for the duration of the test program. In addition, test planning encompasses a consideration of the potential foreign threat factors that will permit a realistic evaluation of the test item in a threat environment. Complete test planning requires that the test officer:

3.1.1 Prepare a test operations checklist using appendix A as a guide.

3.1.2 Incorporate complete safety aspects within the preparation for the test.

3.1.3 Brief participating test personnel on all aspects of the test program, to include the purpose of the test and the precision requirements during test conduct.

3.1.4 Provide sufficient copies of operating instructions to all participating test personnel.

3.2 Facilities. The preparation of the test facilities for the conduct of frequency accuracy and stability tests is straightforward. Items to be considered include:

3.2.1 Lab, bench, and floor space preparation.

3.2.2 Power distribution.

3.2.3 Assembly of necessary tools, operating instructions, loads and equipment handling devices.

3.2.4 Environmental conditions.

3.3 Test Item

3.3.1 A record of the test item nomenclature, manufacturer, technical characteristics and performance parameters is entered into the project notebook.

3.3.2 The test item should be photographed from those perspectives that will result in a non-ambiguous visual identification and representation of the item.

3.3.3 The test item and all associated components relating to the test should be inspected for damage, deterioration and obvious manufacturing defects.

3.3.4 The test item shall be in proper operating condition. This will be accomplished by performing the operational checks, maintenance procedures, alignment and calibration steps specified in the pertinent instruction manual. The intent is to prepare the test item, insofar as possible, to represent average equipment in normal operating condition.

3.4 Instrumentation

3.4.1 The test officer must, during his preparation for the test, verify the availability of all the required test equipment planned for use during the test.

3.4.2 The test equipment must be calibrated before the test starts. All instrumentation must meet or exceed the standards for accuracy and calibration as outlined in paragraph 2.2.1.

3.4.3 Generally, no additional support equipment need be considered during the preparation for test.

3.5 Equipment Setup. The test officer will determine whether a closed-system measurement or open-system measurement is appropriate.

a. Normally, a closed-system measurement will be attempted first. The equipment arrangement for this technique is shown in figure 1. This system of measurement is used when the transmitter under test is designed to feed more than one type of antenna or in situations where the antenna has been designed as an integral part of an aircraft frame.

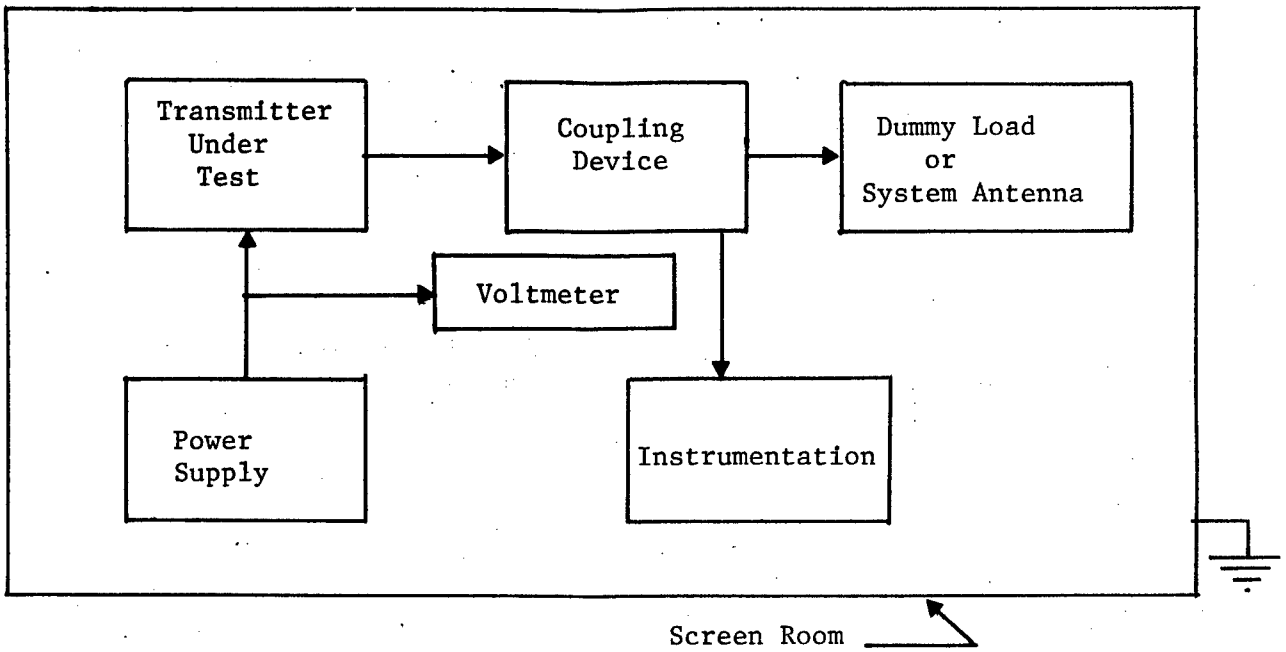

Figure 1 - Closed-System Measurement Setup

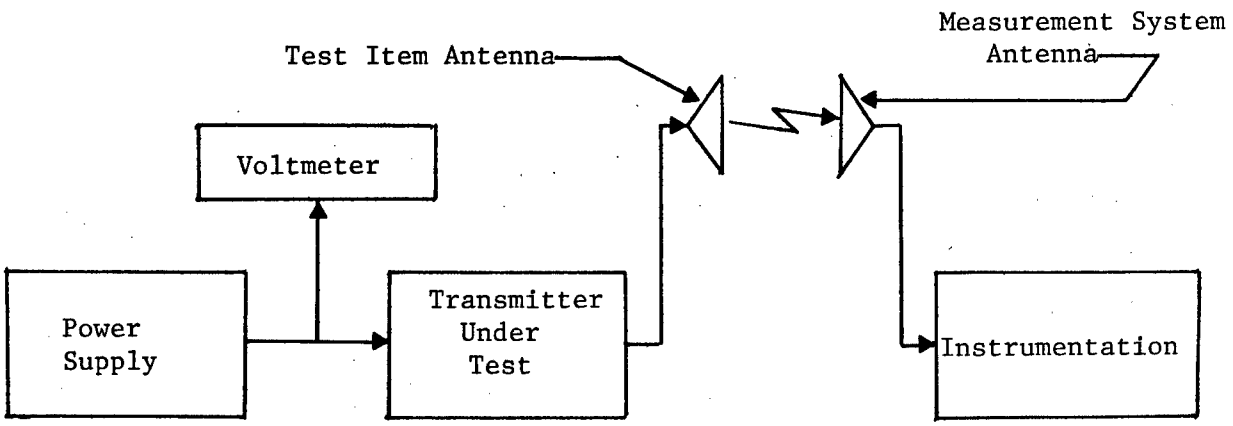

Figure 2 - Open-System Measurement Setup

b. If the transmitter to be tested is designed so that transmitter output is not directly accessible, then the open-system measurement technique is appropriate, with the equipment setup as shown in figure 2. The test item must be completely tested with all antennas designed for use with the transmitter.

4. TEST CONTROLS

4.1 Facilities

4.1.1 The ambient temperature of the test facility should not vary more than 15°F (8.3°C) while conducting comparative and reproducibility tests.

4.1.2 The line voltage used to power both the test item and the instrumentation should not vary more than 2% from the mean while conducting comparative and reproducibility tests.

4.2 Test Item

4.2.1 The test item shall not be moved, adjusted, calibrated, or tuned (except as dictated by the test procedures) while conducting comparative and reproducibility tests. If, while conducting such a test, a test item requires adjustment, the test must be restarted.

4.2.2 Antennas and dummy loads must be constant throughout the conduct of comparative and reproducibility tests.

4.3 Instrumentation

4.3.1 The same instrumentation, without a change in calibration or other adjustments that could affect the measurement of parameters, must be used throughout the test.

4.3.2 All instrumentation must meet the standards for accuracy and calibration as outlined in paragraph 2.2.1.

5. PERFORMANCE TESTS. These procedures address three separate tests. The test officer must plan the conduct of the test such that wasted effort is eliminated by accommodating the requirements of each of the three tests during each setup. For example, the same setup of test item and test equipment may be required for each of the three tests. It is appropriate to conduct those portions of the various tests simultaneously during the common setup. Because one or more of the tests may be inappropriate to a given test item (a single channel emergency transmitter may not require a reproducibility test), each test is outlined entirely. It is the responsibility of the test officer to ascertain which of the tests are appropriate to the test item.

5.1 Deviation. This test will demonstrate the accuracy of the test item's dial setting, meter, read-out, detent, channel selector, etc.

5.1.1 The test item, instrumentation, and ancillary equipment shall be set up as determined by paragraph 3.5.

5.1.2 After the test item, instrumentation, and associated components have been properly interconnected, the appropriate power is applied allowing sufficient time for the equipment to warm up and achieve frequency stabilization. (NOTE: Frequency stabilization has been achieved when the stated tolerances have been reached or the drift rate becomes constant, and the internal equipment temperature has stabilized so that the temperature does not vary more than 15°F [8.3°C] from its average steady state temperature).

5.1.3 Starting at the lowest indicated frequency setting and successively increasing the frequency, measure the actual transmitted frequency. (NOTE: For transmitters equipped with detent stop or channel selection, the frequency at every stop and channel selection must be measured. For transmitters equipped with continuous tuning dials, test frequencies should be selected for each tuning band. The selected frequencies should be located at approximately the 5, 25, 50, 75 and 95 per cent points in each frequency band. Additional test frequencies may be selected, if required, to produce a smooth curve from the test data collected).

5.1.4 The test data will be recorded as indicated in paragraph 6.1.

5.2 Accuracy and Reproducibility. This test will demonstrate the accuracy of tuning after repeated changes of frequency and variations of input-voltage levels.

5.2.1 The test item, instrumentation, and ancillary equipment shall be set up as determined by paragraph 3.5.

5.2.2 After the test item, instrumentation, and associated components have been properly interconnected, the appropriate power is applied allowing sufficient time for the equipment to warm up and achieve frequency stability.

5.2.3 Three standard test frequencies are selected in each tuning band, referred to as "low," "mean," and "high" standard test frequencies, labeled f_1, f_2, f_3 respectively. These frequencies should lie at approximately the 10, 50 and 90 per cent points in each tuning band, respectively. For example, if a tuning band ranges from 50 MHz to 100 MHz, then f_1, f_2, and f_3 would be computed as 55 MHz, 75 MHz, and 95 MHz.

a. Tune and measure the low frequency (f_1). Tune and measure the mean frequency (f_2). Retune and measure the low frequency (f_{1a}). Tune and measure the high frequency (f_3). Retune and measure the low frequency (f_{1b}). The critical information derived at this point is the difference in the measurements of f_1.

$$\Delta f_{1a} = (f_1 - f_{1a}) \text{ and } \Delta f_{1b} = (f_1 - f_{1b}) \quad (1)$$

b. Tune and measure the mean frequency, f_2. Tune and measure the low frequency, f_1. Retune and measure the mean frequency, f_{2a}. Tune and measure the high frequency, f_3. Retune and measure the mean frequency, f_{2b}.

$$\Delta f_{2a} = (f_2 - f_{2a}) \text{ and } \Delta f_{2b} = (f_2 - f_{2b}) \quad (2)$$

c. Tune and measure the high frequency, f_3. Tune and measure the low frequency, f_1 . Retune and measure the high frequency, f_{3a}. Tune and measure the mean frequency, f_2. Retune and measure the high frequency, f_{3b}.

$$\Delta f_{3a} = (f_3 - f_{3a}) \text{ and } \Delta f_{3b} + (f_3 - f_{3b}) \quad (3)$$

d. Steps a, b and c are repeated for at least 10 variations of input voltage levels ranging from 80 to 110 per cent of the rated voltage.

e. The entire test (steps a through d) must be conducted for each tuning band.

5.2.4 The test data will be recorded as indicated in paragraph 6.2.

5.3 Stability. This test will demonstrate the ability of the transmitter to produce the same frequency over a specified period of time. It will also provide an indication of the appropriate warm-up time required for stable operation.

5.3.1 The test item, instrumentation, and ancillary equipment shall be set up as determined by paragraph 3.5, and tuned to the mean standard test frequency (f_2) of the middle tuning band. (See paragraph 5.2.3 for a discussion of f_2).

5.3.2 After the test item, instrumentation, and associated components have been properly interconnected, the appropriate power is applied.

5.3.3 Without waiting for the equipment to warm up, a measurement of the mean carrier frequency shall be taken. The mean carrier frequency reading shall be taken every three minutes for a period of 15 minutes and then every 15 minutes thereafter for the total time as specified for the equipment under test.

5.3.4 Pulsed transmitters shall be tested at both minimum and maximum duty cycle.

6. DATA REDUCTION AND PRESENTATION.

6.1 Data Reduction.

6.1.1 Deviation. Reduce the data items onto a data collection sheet similar to that shown in figure B-1, appendix B.

a. Input voltage level (in volts).

b. Indicated channel setting, dial reading or detent (in Hz).

c. Measured frequency (in Hz).

d. Modulation frequency (in Hz -- single-sideband transmitters only).

e. Pulse width and repetition rate (in M secs and Hz, respectively -- pulsed transmitters only).

6.1.2 Accuracy and Reproducibility: The following data items are required in order to report accuracy and reproducibility. The data shall be recorded on a data collection sheet similar to figure B-2, appendix B.

a. Input voltage level (in volts).

b. Indicated f_1, f_2, f_3, (in Hz).

c. Measured f_{1a}, f_{1b}, f_{2a}, f_{2b}, f_{3a}, f_{3b} (in Hz).

d. Modulation frequency (in Hz -- single-sideband transmitters only).

e. Pulse width and repetition rate (in M secs and Hz, respectively -- pulsed transmitters only).

6.1.3 Stability. The following data items are required in order to report stability. The data shall be recorded on a data collection sheet similar to figure B-3, appendix B.

a. Input voltage level (in volts).

b. Indicated f_2 (in Hz).

c. Elapsed time since turn-on of the measurement of f_2 (in minutes).

d. Measured f_2 (in Hz).

e. Modulation frequency (in Hz -- single-sideband transmitters only).

f. Pulse width and repetition rate (in M secs and Hz, respectively -- pulsed transmitters only).

6.2 Presentation

6.2.1 Deviation is reported in terms of per cent of deviation.

$$\left[\begin{matrix}\text{Per Cent of}\\ \text{Deviation}\end{matrix}\right] = \frac{\left[\begin{matrix}\text{Indicated}\\ \text{Frequency}\end{matrix}\right] - \left[\begin{matrix}\text{Measured}\\ \text{Frequency}\end{matrix}\right]}{\text{Measured Frequency}} \times 100 \qquad (4)$$

a. Note that if the indicated frequency is less than the measured frequency, the percentage is reported as negative. Likewise, if the indicated frequency is greater than the measured frequency, the percentage is reported as positive. When the indicated frequency is the same as the measured frequency, the percentage is reported as zero.

b. The data shall be presented in the tabular form of the Data Collection Sheet, figure B-1, appendix B and in the graphical form of the example of figure B-4, appendix B. The test criteria should be superimposed upon the graphical presentation to assist in the evaluation of the equipment.

6.2.2 Accuracy and reproducibility shall be plotted in the tabular format of the Data Collection Sheet, figure B-2, appendix B. The most meaningful data are the various values of f_1, f_2, f_3 and their associated deltas. The important point of the test is the discovery of the change in the measured frequency when the equipment is tuned and retuned. These deltas are plotted as a function of input voltages using the format shown in the example of figure B-5, appendix B.

6.2.3 Stability is reported in terms of comparative deviation as a function of time (see paragraph 6.2.1). The data are presented in the tabular form of the Data Collection Sheet, figure B-3, appendix B, and in graphical form of the example of figure B-6, appendix B. The test criteria should be superimposed upon the graphical presentation to assist in the evaluation of the equipment.

Recommended changes to this publication should be forwarded to Commander, U.S. Army Test and Evaluation Command, ATTN: DRSTE-AD-M, Aberdeen Proving Ground, MD 21005. Technical information may be obtained from Commander, U.S. Army Electronic Proving Ground, ATTN: STEEP-MT-T, Fort Huachuca, AZ 85613. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A

CHECKLIST FOR TRANSMITTER FREQUENCY ACCURACY AND STABILITY TESTS

	INITIALS	
	Test Officer	Test Supervisor
Availability of appropriate documentation and authority for the conduct of the test program:	_____	_____
Initiate a project notebook:	_____	_____
Establish the project file:	_____	_____
Availability of appropriate references:		
Required Operational Capability (ROC):	_____	_____
Test item specifications:	_____	_____
Military Standards:	_____	_____
Test Operations Procedures:	_____	_____
Operating manuals:	_____	_____
Coordination with test sponsor/contractor:	_____	_____
Are dates for desired test execution realistic?	_____	_____
Availability of test plan to all participants:	_____	_____
Coordination for necessary test support:	_____	_____
Identification of critical test issues:	_____	_____
Test facility conforms to specified standards:	_____	_____
Brief all test personnel:	_____	_____
Instrumentation data have been recorded:	_____	_____
Instrumentation has been currently calibrated:	_____	_____
Test item data recorded in project notebook:	_____	_____
Initial Inspection performed:	_____	_____
Photographs taken of test item(s):	_____	_____
Equipment performance reports prepared:	_____	_____
Data collection sheets are complete:	_____	_____
Test report prepared:	_____	_____

APPENDIX B

DATA COLLECTION SHEETS

DATA PRESENTATION

DEVIATION TEST DATA

Type Setup: Open System_____

Closed System_____

Input Voltage_____

Start Date_____

Modulation Frequency (Single-sideband only)_____

Stop Date_____

Pulse width_____

Test Officer_____

Repetition Rate_____ } pulsed transmitters only

Supervisor _____

Indicated Frequency (a)	Measured Frequency (b)	Deviation (a-b)	Indicated Frequency	Measured Frequency	Deviation (a-b)

Figure B-1

ACCURACY AND REPRODUCIBILITY TEST DATA

Band_____ Type Setup: Open-System_____

Closed System_____

Input Voltage_____(% of norm)

Start Date_____

Modulation Frequency (single-sideband only)

Stop Date_____

Pulse Width_____ } pulsed transmitters only

Test Officer_____

Repetition Rate_____ }

Supervisor _____

	f_1	f_2	f_{1a}	f_3	f_{1b}	Δf_{1a}	Δf_{1b}
Low Frequency							

	f_2	f_1	f_{2a}	f_3	f_{2b}	Δf_{2a}	Δf_{2b}
Mean Frequency							

	f_3	f_1	f_{3a}	f_2	f_{3b}	Δf_{3a}	Δf_{3b}
High Frequency							

Figure B-2

STABILITY TEST DATA

Input Voltage_____

Indicated Frequency (f_2)

Type Setup: Closed-System_____

Open-System_____

Test Officer_____

Supervisor _____

For pulsed transmitters only:

Test data are for:

Maximum duty cycle_____

Minimum duty cycle_____

Time (min)	Measured Frequency	% Comparative Deviation
0		
3		
6		
9		
12		
15		
30		
45		
60		
75		
90		
105		
120		
135		
150		

Figure B-3

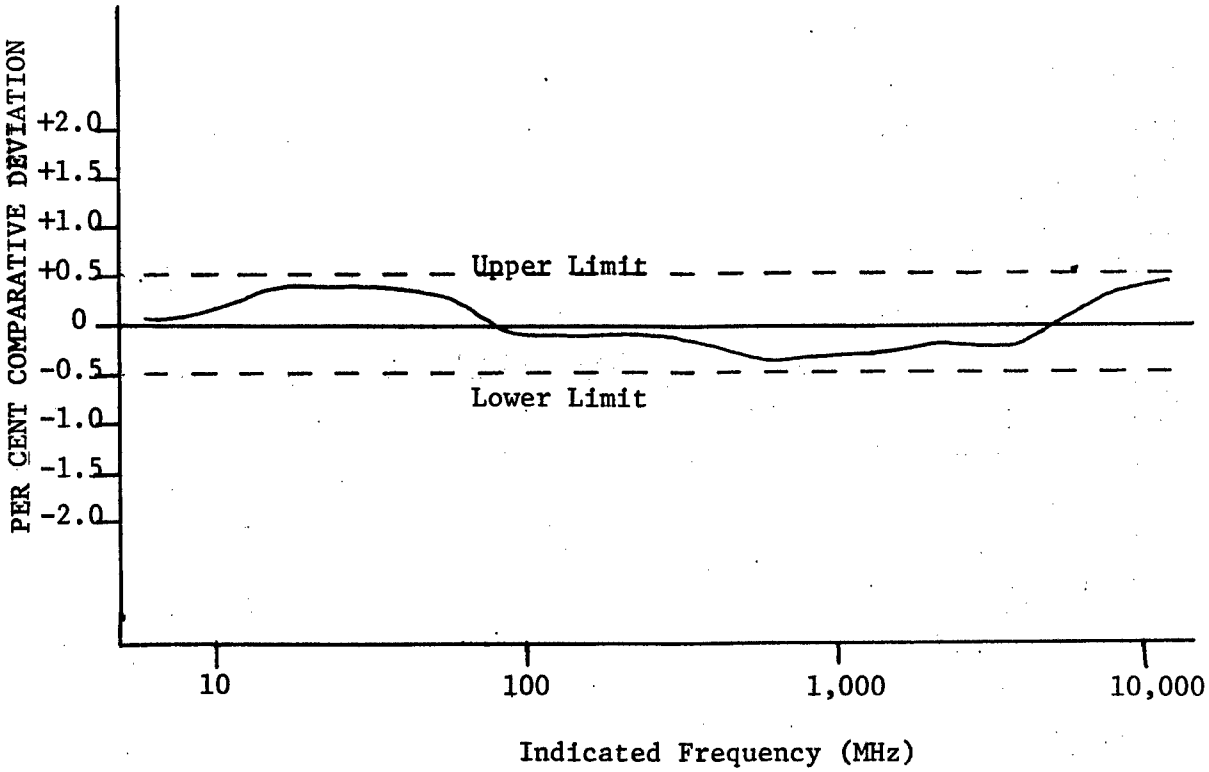

Figure B-4 - Deviation Presentation

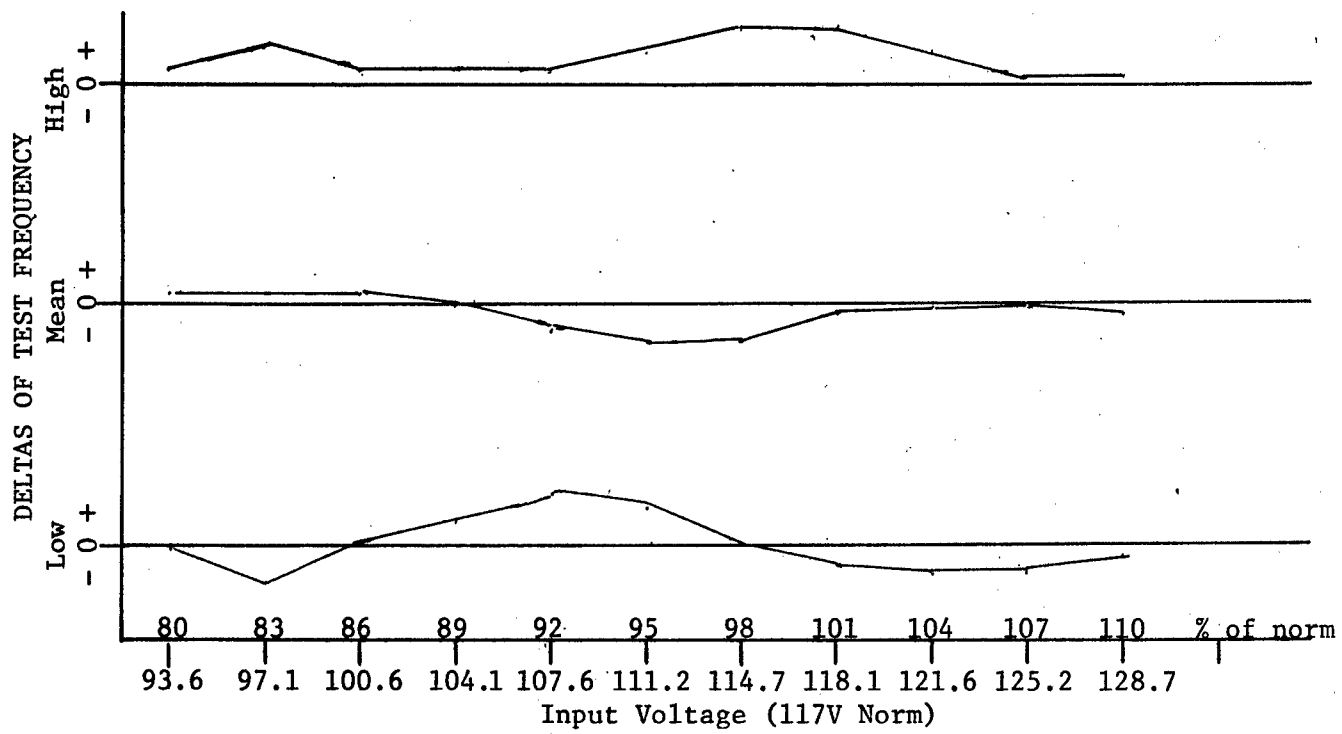

Figure B-5 - Accuracy and Reproducibility

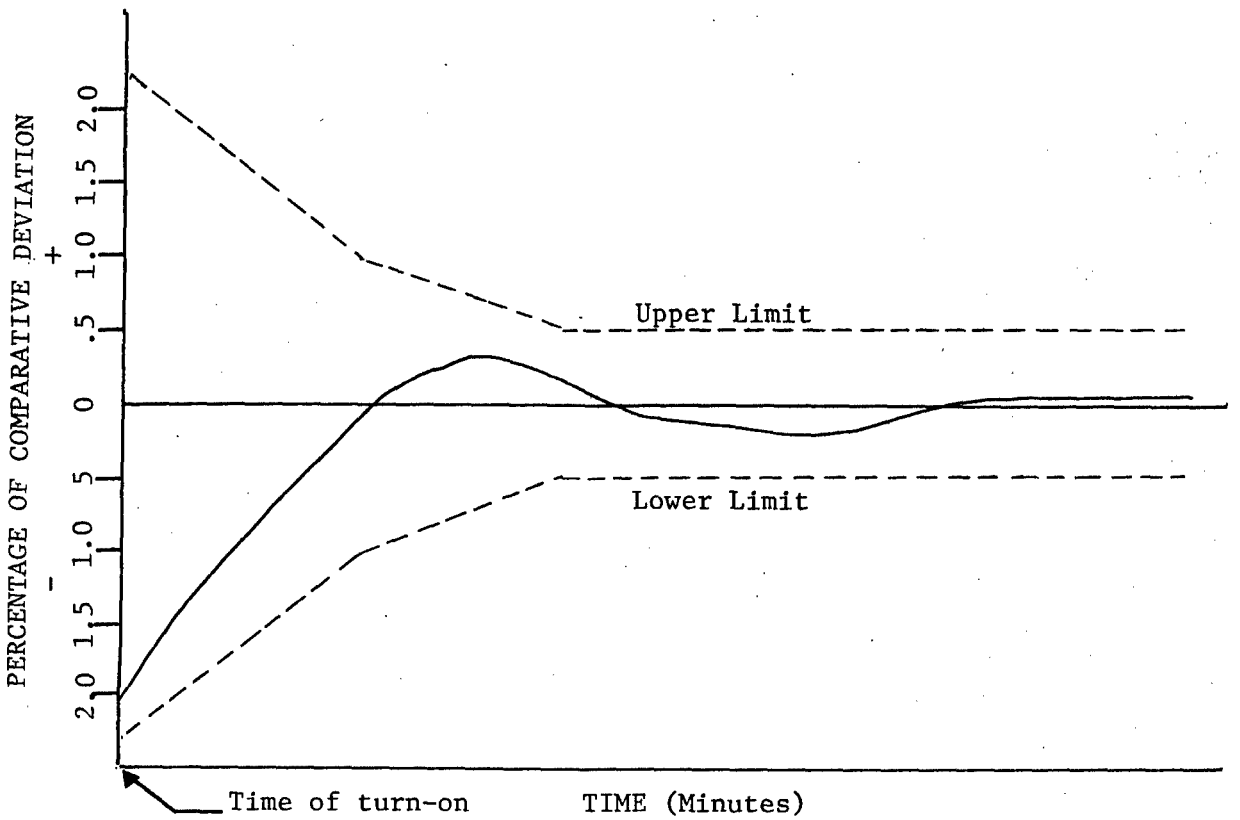

Figure B-6 - Stability